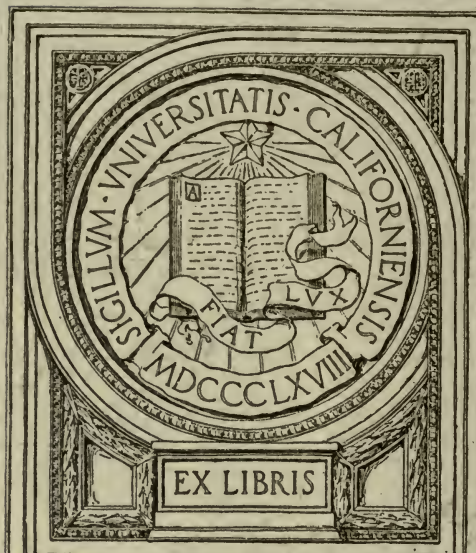
ALKALI
AND
WATER LOGGED
LANDS



E. M. Hilgard

Salt Lake Commercial Club *Bulletin No. One*

Alkali and Water Logged Lands

By THE LANDS COMMITTEE

COMMERCIAL CLUB, Inc.

SALT LAKE CITY

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EDITED BY
W. C. ALEXANDER, Chairman
Lands Committee

Acknowledgment.

IN PRESENTING this bulletin to the public, the Salt Lake Commercial Club, through its Lands Committee, wishes to acknowledge its indebtedness to the following authorities on the subject of reclamation, and to express its appreciation for the generous responses to requests for the articles contained in this, the first of a series of bulletins it is proposed to publish.

E. W. HILGARD, L.L.D., Ph.D.,
Chemist (Emeritus) of the University of California.

ROBERT STEWART, B.S., Ph.D.,
Chemist of the Utah Agricultural College.

E. D. BALL, B.S., M.S., Ph.D.,
Director of the Utah Agricultural Experiment Station.

L. A. MERRILL, B.S.,
Agricultural Expert Salt Lake Route and United States Mining, Smelting and Refining Company.

R. A. HART, B.S., C.E.,
Supervising Drainage Engineer of the United States Department of Agriculture.

J. C. WHEELON,
Chief Engineer of the Utah-Idaho Sugar Company.

It is to be hoped that the articles herein will correct, in a measure, the general misapprehension regarding alkaline soils. "Alkali," as the term is commonly used in the west, conveys to the average mind some harmful substance whose presence in soils renders the land practically valueless from an agricultural standpoint. That the prevailing opinion is contrary to the fact is shown by the contributions to this publication, notably in the initial article by Prof. E. W. Hilgard.

Introduction.

THE OBJECT of this bulletin is to place before the public authoritative information regarding the practicability of reclaiming by means of sub-drainage, alkaline and water-logged lands generally, and with specific reference to and urging the development of the major portion of an area of land approximating 50,000 acres lying between Salt Lake City and Great Salt Lake.

This area of desert—and in many sections unsightly—waste is in excess of ten per cent of the total acreage of Salt Lake County, and is equal to forty per cent of its improved land in farms.

The articles contained in this issue, which have been generously contributed by authorities, whose opinions are final in all matters pertaining to reclamation, should leave in the minds of even the most skeptical, no doubt whatever relative to the feasibility of successful reclamation of alkaline and water logged lands by means of drainage.

There can be no question regarding the efficiency of drainage, but largely influencing its economic success is the factor of proper outlet for drainage waters. It therefore follows that in every district where a drainage system is contemplated, this primary element should be the subject of careful investigation.

Topographical conditions under which successful drainage of the land west of this city must be accomplished, are such as to require much attention to this important feature. The altitude of the land with reference to the varying levels of Great Salt Lake (upon which depends the practical operation of a gravity drainage system) renders this consideration one of unusual importance. To the end of supplying a small measure of accurate information on the subject of elevations, the Commercial Club secured the services of a competent engineer, who

ran levels from the lake to the central portion of the tract under consideration. The result of his work dispels any doubt whatever regarding the sufficiency of outlet for gravity drainage for approximately ninety per cent of the land traversed, basing the elevation of discharge upon the average level of Great Salt Lake for the past quarter of a century. A graphical chart indicating the relative land and varying lake levels, together with a brief report and map of Salt Lake County by the engineer will be found elsewhere in this issue.

It is not the purpose of the Commercial Club to enter into a technical discussion relative to engineering, the sufficiency of water for irrigation or other features involved in the ultimate reclamation of this great tract, or, to pass upon the merit of any existing enterprise. It is the development of the tract as a whole in which this club is interested to the end that it may conform to the otherwise unsurpassed environment of Salt Lake City.

ECONOMIC CONDITIONS

To the most casual analyst of local opportunity for profitable investment in a drainage enterprise, it must be readily apparent that this area possesses exceptional economic advantages. It lies within a short distance of Salt Lake City, which affords the largest as well as the best market in Utah for all produce and is the distributing center of the intermountain west. Its proximity to the city offers superior educational and social advantages with little inconvenience, and nowhere within the State is to be found an undeveloped area, similar in extent, which is so well served with all classes of public utilities.

The transportation facilities are exceptional. Extending through the central portion of the tract is the Salt Lake & Los Angeles (Saltair) Railroad, and to the south, within a distance of less than two miles from it, are the lines of the Salt Lake Route and the Western Pacific Railroads. Electrical energy for commercial and domestic purposes is easily available from the transmission system of the Utah Power & Light Company, while telephone and telegraph service may be obtained from the lines which traverse this area. Topographical conditions are such that highways of very light grades, leading to almost every section, may be constructed and maintained at very low cost.

RECLAMATION

The feasibility of successfully reclaiming these lands by means of drainage has advanced beyond the experimental period. This statement has been confirmed by the United States Department of Agriculture, acting jointly with the Utah Agricultural Experiment Station on what is known as the "Swan Tract," an area of forty acres in Section 5, Township 1 south, Range 1 west, on the line of the Western Pacific Railroad. This acreage was selected as representative of perhaps the worst possible soil condition to be found on the tract. Not only was the land water logged but the alkaline content so high that, in places

upon its salt incrusted surface, even native plant growth was utterly impossible. Within the short period of a year, this farm, under intelligent management, produced a satisfactory crop and is now regarded as being the best "40" west of the city. A brief article by Prof. L. A. Merrill regarding the results of this experiment will be found in this booklet.

An entirely successful demonstration of drainage reclamation by private enterprise, under conditions similar to those of the Swan Tract, has been a recent accomplishment by the Utah-Idaho Sugar Company in Bear River Valley under the able direction of its chief engineer, J. C. Wheelon, by whom an instructive article has been contributed. The articles by Prof. E. D. Ball of the Utah Agricultural Experiment Station, R. A. Hart of the Department of the Interior and Mr. Wheelon, regarding the practicability of reclaiming worthless lands by means of drainage, should be thoroughly convincing.

SOIL

Concerning the chemical composition of the soil of this tract (aside from its alkaline content), it is shown by analyses that the elements essential to plant growth are found in such quantities as to assure commercial agricultural success. The Utah Agricultural Experiment Station, in co-operation with the Bureau of Soils of the United States Department of Agriculture, at the time the soil survey of this tract was made, collected some fifty samples from various portions of the land, and included in this bulletin is an exhaustive article by Prof. Robert

Stewart of the Utah Agricultural Experiment Station, thoroughly covering this essential subject and which, through his courtesy, is for the first time given to the public.

From the foregoing and the articles following, two conclusions, at least, will be reached: First, that this area offers unusual opportunities for investment in drainage enterprises, from which very exceptional profits may be realized. Second, and far the more important from a civic viewpoint—the transformation of this, the most conspicuous waste in Utah, into productive fields and gardens.

PUBLIC OPINION

The environs of Salt Lake City, with the single exception of this area, are rarely equaled. The beauty of the surrounding scenery is nowhere in the west surpassed. Particularly is this true of its many magnificent canyons, but, unfortunately, the greater percentage of visitors rarely spend sufficient time here to visit them and their opinions are largely based upon observations from passing trains. The railroads leading north and south from this city traverse a country, the greater portion of which is under a high state of cultivation; the fields and orchards with their background of majestic mountains bear silent testimony to the fertility of the soil and industry of the people. The impression on the traveler is salutary.

In striking and disagreeable contrast is the impression received in traveling westerly through the area under discussion. Traversing its southern boundary are two transcontinental lines, the Western Pacific and Salt Lake Route, while bisecting it is the Saltair Railroad which, during the summer season, carries constantly increasing thousands of visitors to Utah's world-famous lake and its equally famous resort—Saltair.

The opinion which all travelers automatically form in traversing this unsightly forbidding waste is justly unfavorable and one which at best cannot but reflect negatively upon an otherwise progressive community.

The advertising value of favorable expression by travelers concerning any section of the country visited is difficult to measure. Its

influence is far reaching and very often the pleased visitor becomes a satisfied investor and frequently a resident.

Pleasing environment of a well equipped city offers an unconscious inducement to the itinerant to prolong his visit, during which the active man of business is certain to inquire relative to local conditions and opportunities. The longer the visitor remains the greater the likelihood of his engaging in the affairs of the community. This interest in turn extends to his associates, all of which tends to the upbuilding of the state.

It is outside capital for development of which all western states stand in need. Nowhere in the intermountain west do so many opportunities exist as in Utah, a state which has within its boundaries all of the resources of an empire. No western state stands more in need of financial assistance to develop its wonderful resources than Utah—resources which are as yet, practically untouched and local capital, however actively it may be employed, is far from sufficient to realize even a fraction of the results which are possible with the opportunities everywhere at hand.

CONCLUSION

Agricultural expansion of the arid states is restricted by reason of topographical conditions or scarcity of water, to comparatively narrow limits. This unquestionably applies to the State of Utah generally and to Salt Lake County in particular. Considering the limited undeveloped area in this country which is susceptible of cultivation and its proximity to the largest city in the State, it is difficult to determine the cause for its present condition. That the soil is alkaline should afford no ground for apprehension regarding the ultimate result of development. The practical demonstration on the "Swan Tract" has long since proven its feasibility. But one logical reason seems to remain—the lack of publicity concerning the truth relating to the successful reclamation of this class of land and the intrinsic value of this particular tract.

In presenting this bulletin, it is with the desire that it may prove, in a measure at least, educational and if there shall follow as a result of this effort to correct erroneous impressions, a measure of activity leading to the development of this tract, the endeavors of the Salt Lake Commercial Club to that end, through its Lands Committee, will not have been in vain.

A WELL KNOWN FARM LOCATED SOUTH OF SALT LAKE CITY.

Indicates the agricultural development which is possible to equal in the area west of the city.

A TYPICAL FARM NORTH OF SALT LAKE CITY UNDER A HIGH STATE OF CULTIVATION.

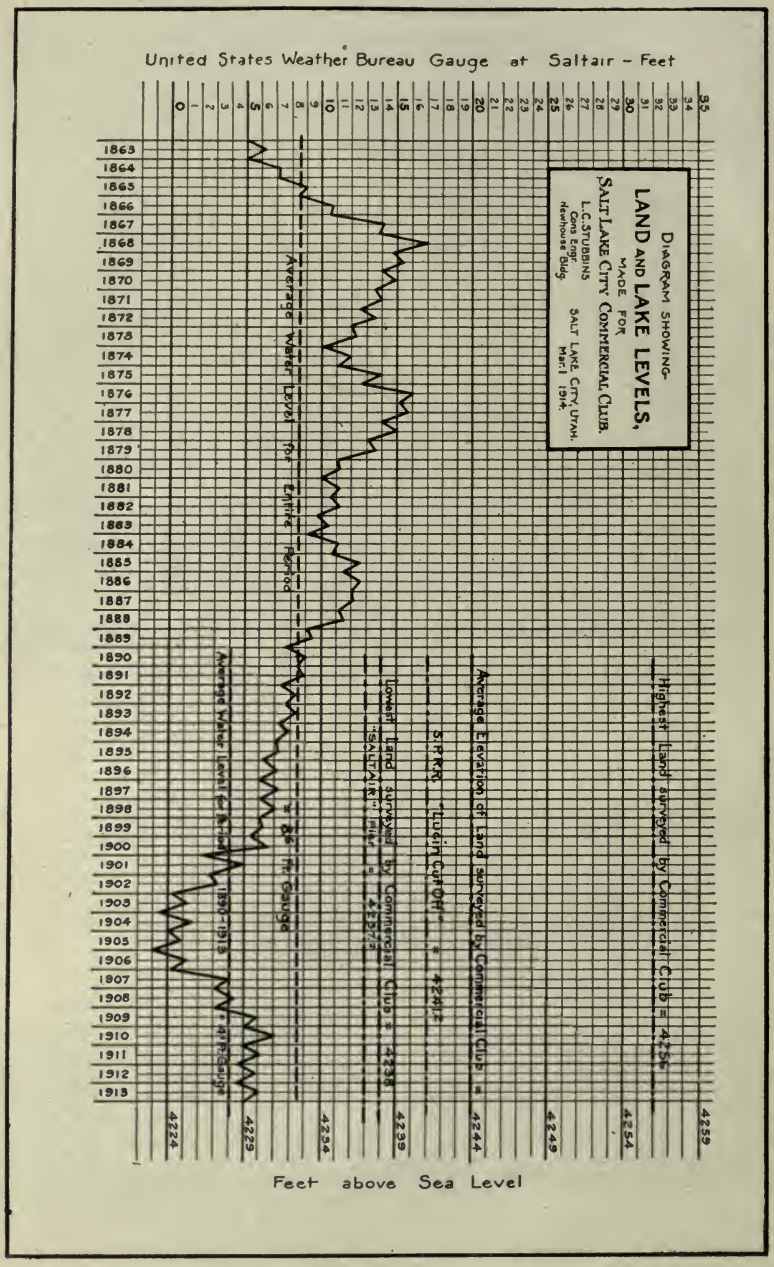
This farm, with many others, adds to the environment of Utah's metropolis.

Mr. W. C. Stark,
Secretary Commercial Club,
Salt Lake City.

In response to your request that I should give to you some special expression of my views regarding alkali lands and their cultural value I might say, summarily, that both chemical investigation and practical experience have shown that when such lands are once freed from excess of salts which injure useful vegetation they prove exceptionally and lastingly productive; more so even than the non-alkaline lands lying adjacent. The fact that they result from the failure of adequate rainfall to leach out the salts at once indicates that all the active soil ingredients are retained, the useful ones as well as the useless, so that so soon as the useless or injurious salts like common and Glaubers salts and carbonate of soda are removed there remains an accumulation of plant food which for a long time renders fertilization unnecessary, provided only that proper deep cultivation is practiced and maintained, so that the crop roots can reach the great depths to which the available soil almost always reaches in these lands. They are therefore eminently adapted to intensive culture, such as truck-farming, where markets are available. The maintenance of good surface mulch of loose soil, to prevent unnnecessary evaporation from the surface, is of course as needful in alkali lands as in other dry-farming soils of the arid region. But owing to the remaining saline ingredients, reclaimed alkali soils are always more easily kept in a moist condition which greatly helps vegetation.

While the reclamation of alkali lands by drainage is somewhat expensive in extreme cases, there is a large porportion of them that, while showing some salts on the surface before cultivation, may be made to produce large crops by deep and thorough tillage and the maintenance of a good surface mulch, alone. The one deficiency of most of these lands is lack of humus, but this can readily be made up by turning under the abundant vegetation they produce.

E. W. Hilgard.


United States Weather Bureau Gauge at Saltair - Feet
DIAGRAM SHOWING
LAND AND LAKE LEVELS,
MADE FOR
SALT LAKE CITY COMMERCIAL CLUB.
L.C. STUBBINS
Cons Engr.
Newhouse Bldg.
SALT LAKE CITY, UTAH.
Mar 1 1914.
Highest Land surveyed by Commercial Club = 4259
4254
Average Elevation of Land surveyed by Commercial Club = 4244
4249
STERR. Luzin Datum = 4241.5
Lowest Land surveyed by Commercial Club = 4234
4239
SALTAIR. Datum = 4232.2
Average Water Level for Entire Period
Average Water Level for 1850-1913
4229
4224
4234
Feet above Sea Level

Salt Lake City, Utah,
January 2nd, 1914.

Mr. W. C. Alexander,
Chairman Lands Committee Commercial Club,
Salt Lake City, Utah.

DEAR SIR:

Complying with your instructions, I ran levels on the Salt Lake Meridian from Salt Lake City to Great Salt Lake, connecting with the guage of the United States Weather Bureau at Saltair. When running these levels, I took the elevation of certain lands lying adjacent to the Meridian which are indicated on map of Salt Lake County, herewith.

The levels taken disclose the following facts:

(1) The elevation of the present level (January 1st, 1914) of Great Salt Lake is 4229 feet above sea level.

(2) The elevation of the highest land (near Ewing Station) covered by these levels is 4256.

(3) The elevation of the lowest land surveyed (near the works of the Inland Crystal Salt Co.) is 4238.

(4) The average elevation of land covered by these levels is 4244 feet above sea level. (All elevations refer to Salt Lake City datum.)

Therefore, the greater portion of the land surveyed is susceptible of gravity drainage with outlet into Great Salt Lake with tile placed at a depth of five feet under ground, so long as the water level of the Lake remains below a reading of thirteen (13′) feet on the guage of the United States Weather Bureau at Saltair.

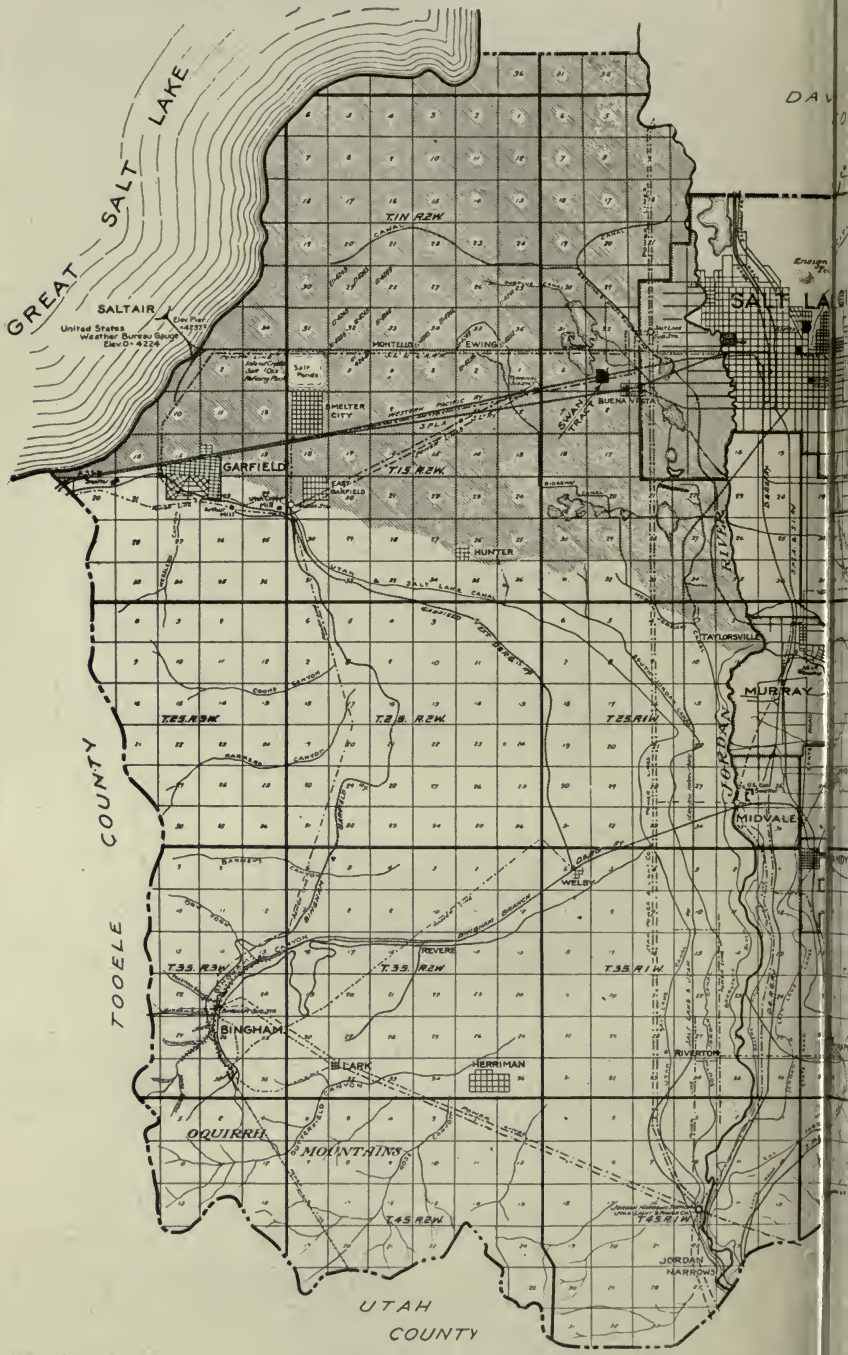
Should the water level of the Lake arise above this level, a gravity system of drainage would fail and a pumping system would be required.

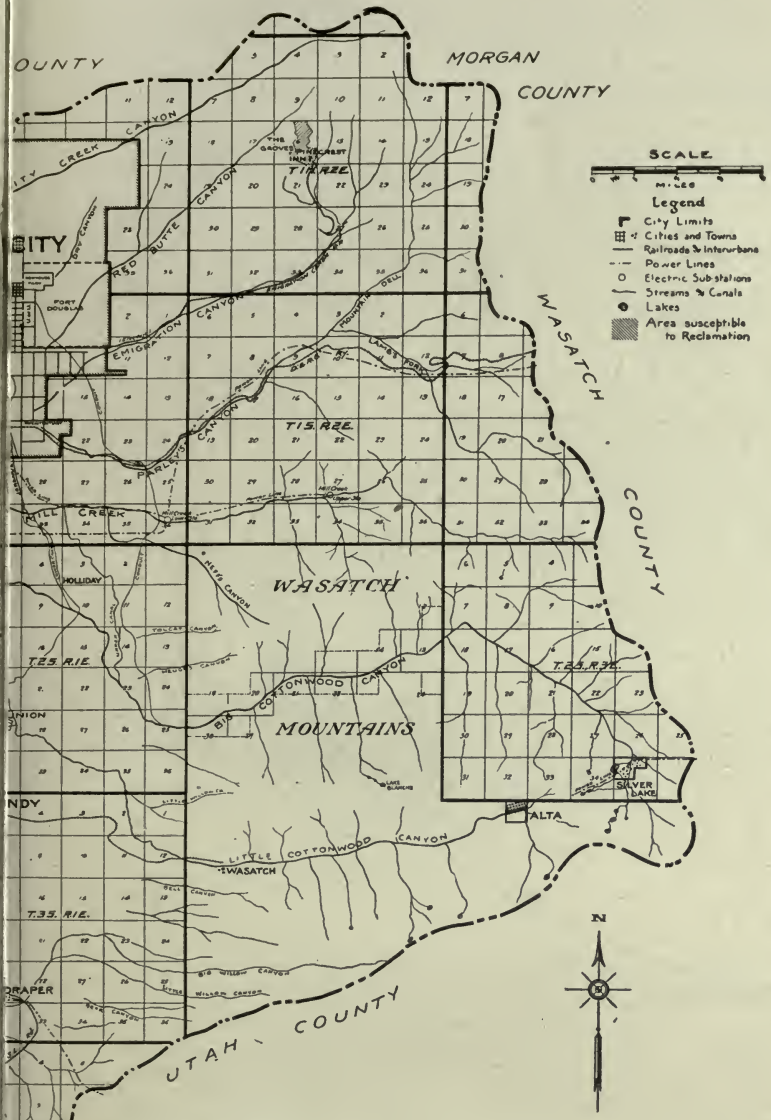
In order that some opinion may be formed as to the possibility of the Lake attaining to that height, I am submitting herewith a diagram showing the fluctuations of the Lake from the year 1862 to date. On this diagram are indicated the elevation of the Lucin Cut Off of the Southern Pacific Railroad across the Lake and the pier at Saltair, also the elevations of the land surveyed.

Yours very respectfully,

L. C. STUBBINS, C. E.

Chief Engineer Richlands Irrigation Co.


GREAT SALT LAKE
SALTAIR
United States Weather Bureau Datum Elev. 0 - 4224
Dev Pier
MONTELLO
EWING
SALT LA
SMELTER CITY
BUENA VISTA
GARFIELD
EAST GARFIELD
HUNTER
T.1 N. R.2 W.
T.1 S. R.2 W.
TAYLORSVILLE
MURRAY
T.2 S. R.2 W.
T.2 S. R.3 W.
T.2 S. R.1 W.
MIDVALE
WELBY
REVERE
T.3 S. R.3 W.
T.3 S. R.2 W.
T.3 S. R.1 W.
BINGHAM
LARK
HERRIMAN
RIVERTON
OQUIRRH MOUNTAINS
T.4 S. R.2 W.
T.4 S. R.1 W.
JORDAN NARROWS
TOOELE COUNTY
UTAH COUNTY
JORDAN RIVER



MAP OF

SALT LAKE COUNTY, UTAH

FOR SALT LAKE COMMERCIAL CLUB

L.C. STUBBINS.
Consulting Engr.
Newhouse Bldg.
Salt Lake City, Utah.

To accompany BULLETIN No 1
of the LANDS COMMITTEE
W.C. ALEXANDER, Chairman.

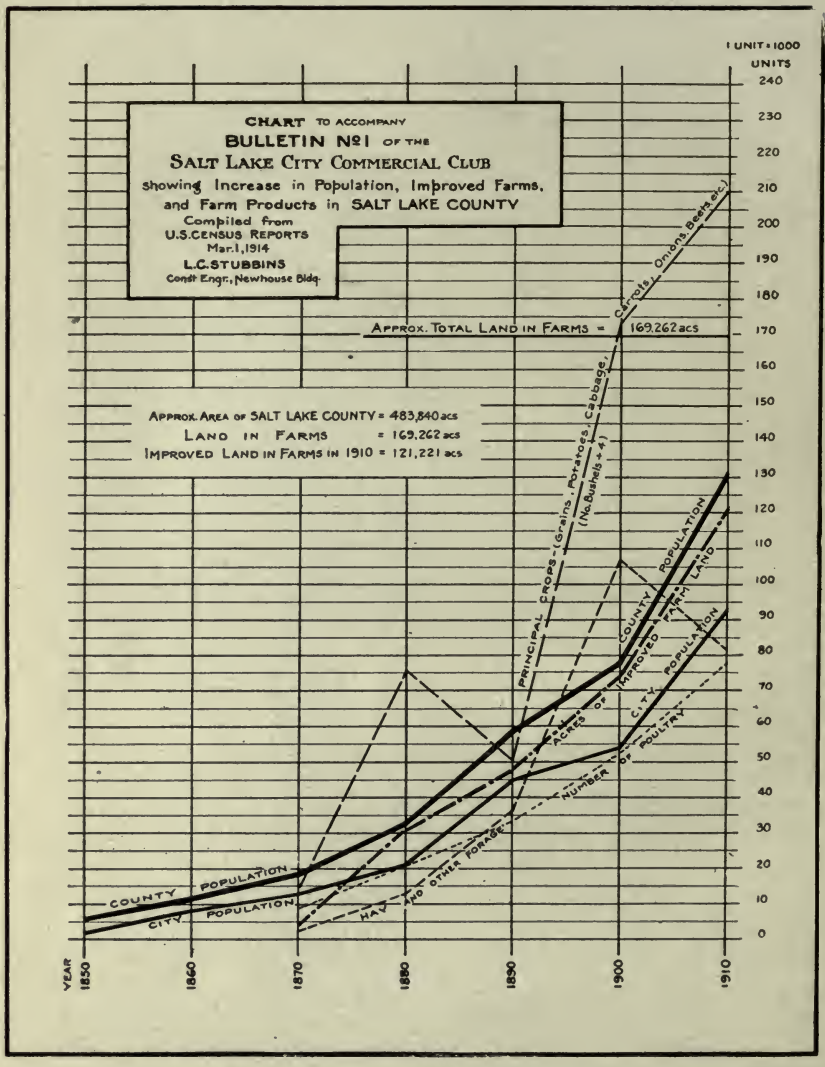


CHART TO ACCOMPANY
BULLETIN Nº1 OF THE
SALT LAKE CITY COMMERCIAL CLUB
showing Increase in Population, Improved Farms, and Farm Products in SALT LAKE COUNTY
Compiled from U.S. CENSUS REPORTS Mar. 1, 1914
L.C. STUBBINS
Const Engr., Newhouse Bldg.
APPROX. AREA OF SALT LAKE COUNTY = 483,840 acs
LAND IN FARMS = 169,262 acs
IMPROVED LAND IN FARMS IN 1910 = 121,221 acs
APPROX. TOTAL LAND IN FARMS = 169,262 acs
1 UNIT = 1000 UNITS
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
YEAR
1850
1860
1870
1880
1890
1900
1910
COUNTY POPULATION
CITY POPULATION
HAY AND OTHER FORAGE
PRINCIPAL CROPS - (Grains, Potatoes, Cabbage, Carrots, Onions, Beets etc.) (No. Bushels ÷ 4)
NUMBER OF POULTRY
ACRES OF IMPROVED FARM LAND
COUNTY POPULATION
CITY POPULATION

THE SOILS OF SALT LAKE COUNTY

BY

ROBERT STEWART, CHEMIST, UTAH EXPERIMENT STATION.

A complete soil survey of the region lying west of the Jordan River in Salt Lake County, Utah, was made in 1899 by the Utah Experiment Station in co-operation with the Bureau of Soils of the United States Department of Agriculture. The physical and alkali conditions of the area are quite thoroughly discussed in the report of the survey which may be obtained from the United States Department of Agriculture, or from the Utah Experiment Station. In this report no discussion was made regarding the plant-food content of the soil and it is therefore the purpose of this article to give a brief discussion of the fertility of the soil from the viewpoint of plant-food actually present in the soil.

At the time of the survey, samples of soil representative of the important soil types to a depth of twelve (12) inches were carefully collected and preserved for chemical analysis. The Jordan Sandy loam comprises above 30% of the area investigated. Gardner and Stewart in their report of the survey say, "The Jordan Sandy loam is easily cultivated and is sufficiently fertile to produce almost any class of crops. It forms the most valuable portion of the low salty area, because of the ease with which it may be reclamed by underdrainage and washing."

The analysis of these samples of soil from this type are reported in

TABLE 1. *Phosphorus, Potassium and Nitrogen in Jordan Sandy Loam.*
(Results expressed as pounds per two million of soil.)

Laboratory No.	Description and Location of Samples	Phosphorus	Potassium	Nitrogen
19523	NE Corner of SE Quarter of Sec. 27, Township 3 S, Range 1 W.....	2800	18600	2400
19527	South Center of Sec. 22, Township 1 S, Range 1 W.....	5600	11600	5420
19536	Near NE Corner of Sec. 15, Township 2 S, Range 1 W.....	4400	10200	2160
19537	SE Corner of Sec. 5, Township 2 S, Range 1 W	4600	21000	3460
19538	E Center of Sec. 3, Township 2 S, Range 1 W.....	3800	21000	2520
19539	N Center of Sec. 10, Township 2 S, Range 1 W.....	4000	12400	2900
19542	N Center of Sec. 27, Township 2 S, Range 1 W.....	3800	15600	3300
19544	NE Corner of Sec. 29, Township 2 S, Range 2 W	6800	15000	3300
19545	Near S. Center of Sec. 18, Township 1 S, Range 2 W.....	2800	5400	2660
19547	SW Corner of Sec. 22, Township 1 S, Range 2 W	4800	16200	2120
19548	SE Corner of Sec. 28, Township 1 S, Range 2 W.....	2400	12000	3000
19550	S Center of Sec. 1, Township 1 S, Range 2 W	2200	13600	2080
	Average.....	4000	12633	2948

The soils of this type are very rich in phosphorus. A soil containing 2200 pounds of phosphorus per two million pounds of soil is regarded as rich in this element. It will be noted that none of the samples analyzed contain a smaller quantity of phosphorus than this, while the average amount of phosphorus present is 4000 pounds per two million pounds.

The potassium content is also high. A soil containing 11500 pounds of potassium per two million of soil is abundantly supplied with potassium. Only one sample falls below this amount, and many of them greatly exceed it, while the average amount is greater by 1100 pounds. With the proper methods of cultivation the amount of potassium present is sufficient for indefinite periods of time for ordinary general farm crops.

The amount of nitrogen present is as in all arid soils, somewhat low—but by the proper utilization of the ability of legume crops to secure nitrogen from the air this deficiency can easily be corrected in a proper system of agriculture.

TABLE 2. *Phosphorus, Potassium and Nitrogen in Jordan Meadows.*
(Results expressed as pounds per two million of soil.)

Laboratory No.	Description and Location of Samples	Phosphorus	Potassium	Nitrogen
19524	NE Corner of NW Quarter of Sec. 14, Township 3 S, Range 1 W.....	2600	14600	2020
19540	NE Corner of Sec. 11, Township 2 S, Range 1 W.....	3200	17000	5820
	Average.....	2900	15800	3920

The composition of the soil of the Jordan Meadows is indicated in Table 2. The conclusions arrived at by a study of the results for the Jordan sandy loam, apply here also.

TABLE 3. *Phosphorus, Potassium and Nitrogen in the Jordan Loam.*
(Results expressed as pounds per two million of soil.)

Laboratory No.	Description and Location of Samples	Phosphorus	Potassium	Nitrogen
19525	About 2 miles NE of Harriman, Township 3 S, Range 1 W.....	2600	17000	1780
19526	NW Corner of Sec. 29, Township 1 S, Range 1 W.....	3400	14000	2520
19541	NW Corner of Sec. 4, Township 1 S, Range 1 W.....	2800	15800	2260
19543	Near Center of Sec. 28, Township 2 S, Range 1 W.....	3400	16000	2440
	Average.....	2800	15700	2225

The composition of the Jordan loam is shown in Table 3. This soil like the Jordan Meadows and Jordan sandy loam is well supplied with the elements of plant food.

TABLE 4. *Phosphorus, Potassium and Nitrogen in Jordan Clay.*
(Results expressed as pounds per two million of soil.)

Laboratory No.	Description and Location of Samples	Phosphorus	Potassium	Nitrogen
19546	N Center of Sec. 5, Township 1 S, Range 2 W.....	1400	13000	1260

The composition of the Jordan clay is indicated in Table 4. This is a much poorer type of soil than the others since it contains only half as much phosphorus and nitrogen. Soil of this type is also very compact and difficult to drain.

TABLE 5. *Phosphorus, Potassium and Nitrogen in Soils on Higher Lands of Salt Lake County.*
(Results expressed as pounds per two million of soil.)

Laboratory No.	Description and Location of Sample	Phosphorus	Potassium	Nitrogen
19528	Near E Center of Sec. 29, Township 1 S, Range 1 E.....	3000	14800	4860
19529	Near W Center of Sec. 14, Township 2 S, Range 1 E.....	3800	17200	2740
19530	E Center of Sec. 17, Township 2 S, Range 1 E	3000	11600	2960
19531	E Part of NW Quarter of Sec. 32, Township 2 S, Range 1 E.....	2600	7800	3500
19534	Near Center of SW Quarter of Sec. 31, Township 1 S, Range 1 E.....	3600	14000	2400
19535	NW Corner of Sec. 19, Township 1 S, Range 1 E.....	4200	13000	5740
	Average.....	3370	13400	3200

The results in Table 5 show the composition of the older cultivated lands in the vicinity of Murray. They are given here for comparison. It may be noted that the soils west of Salt Lake are nearly as well supplied with nitrogen and potassium and far more abundantly supplied with phosphorus. Sufficient accurate chemical evidence is thus presented upon which to base a confident statement that the soils are well supplied with the chemical elements of fertility. *If the salts are permanently removed by adequate drainage the soil should be converted into fertile farms. Attention should be called to the fact that in the removal of alkali salts by drainage the tilth of the soil may be destroyed temporarily, but this condition can easily be remedied by the introduction of organic matter in the form of barnyard manure or by plowing under a green manure crop.*

REDEEMING ALKALINE LANDS

BY

E. D. Ball, Director, Utah Experiment Station.

If the wealth of a state is to be measured by the amount of its undeveloped resources, then Utah may be reckoned as one of the wealthy states.

At the present time, both Government funds and private capital in large amounts are being used to develop new irrigated sections that will ultimately bring greatly increased areas under cultivation, establish new towns and cities and build up those already here. Some of these projects are far from markets and lack transportational facilities and even with good soil and water, will develop slowly until these conditions change. Without the irrigation project, these conditions would probably never be changed and development of new territory without the "pioneer" stage is impossible.

There are, however, immense areas in the state that are close to established cities and towns, with transportation facilities already at hand, which offer just as tempting a field for investment as do the irrigation projects now building.

The "pioneering" in this case will have to be done by the company that develops them and not by the settlers after they are developed and there seems to be the rub,—pioneering work is alright—for the other fellow.

The areas referred to are the alkali flats west of Salt Lake City and other similar tracts extending along the Wasatch Range. Taken altogether there is an immense area of such land in the state. Land where, if once reclaimed and made productive, the settlers could enjoy, right from the start, all the advantages of proximity to markets, rural free delivery and social and educational advantages of well developed communities.

Experiments already carried on by the Agricultural College and the U. S. Government Drainage Department, working in co-operation have shown that the alkali can be worked out of the land at reasonable cost and that once the alkali is removed, the land can, with the time and labor necessary to develop any virgin soil, be brought under cultivation and profitable crops produced.

Just why the lands have not been developed previous to this is hard to understand. It certainly cannot be the cost, as experiments have proven that it will cost less to reclaim this land than it will to furnish water to any of the irrigated projects under way at the present time. It certainly cannot be the lack of water to wash out the alkali because the washing could be done in the spring or fall when the water was not in use. It cannot be the time involved in the washing process, a matter of two or three years, as many projects have taken much longer time than that. The only apparent explanation is the one suggested before, that corporations do not like to "pioneer." Their engineers have had

no experience in the line of work and cannot furnish them estimates with the accuracy of an irrigated project and they therefore much prefer the beaten path.

The agricultural possibilities of these lands, for trucking and market gardening are too great, however, for them to remain idle much longer. Some courageous corporation will pave the way and then there will be a scramble to get in on what must ultimately prove to be a profitable investment.

There is no need, however, for capitalists to hesitate on this project. Agricultural experts are at hand to examine and select lands that have the most favorable soil conditions. Drainage engineers can give close estimation of the cost of installing a drainage system with laterals close enough to wash out the alkali in a reasonable time. Irrigation engineers can figure the cost of bringing water to the land and the cost of leveling and diking to hold the water. Anyone can figure the cost of watering the land to wash out the alkali, the water will do the rest.

After the land has been washed free of harmful amounts of alkali then the soil will need stirring and washing for a year to overcome the effects of the puddling and washing to bring it into condition to grow crops, but any raw land must be worked up and subdued before it is profitably farmed.

DRAINAGE OF ALKALI LANDS

BY

PROF. LEWIS A. MERRILL, AGRICULTURAL EXPERT SALT LAKE ROUTE AND SECRETARY UTAH STATE CONSERVATION COMMISSION

For several years past the feasibility of reclaiming water-logged and alkali lands by tile-drainage has been urged by Government and State Officials. Some twelve years ago the writer, who was then connected with the Utah Experiment Station, represented the state in a co-operative experiment with the Government in an attempt to reclaim a forty acre tract near Salt Lake City.

Irrigated lands in Salt Lake valley are worth from $125.00 to $250.00 per acre, and if adjacent to Salt Lake City and free from alkali are worth much more. There is plenty of good tile clay in the vicinity of Salt Lake City and tile can be and is manufactured here at a reasonable cost. Experience has shown that these lands can be drained at a cost of less than $25.00 per acre. It is apparent, therefore, that there is here an opportunity for a material addition to the wealth and population of Salt Lake valley.

Careful estimates show that there are at least 90 square miles between Salt Lake City and the lake that can be drained; lands that at present have but a nominal value, but if properly drained would be worth at least six million dollars.

That the drainage can be successfully accomplished and the alkali removed *has already* been demonstrated. In 1902 the "Swan tract," consisting of 40 acres, lying 4 miles west of Salt Lake City in Sec. 5 Township 1 S., R. 1 W., was underlaid with tile at a cost of $660.00

This land was strongly impregnated with alkali salts and was considered practically valueless. After installation of tiles, the land was flooded practically each week for an irrigation season.

Before any water was applied to the tract, however, a detailed survey was made to determine the alkali content of the soil. The following table gives the tonnage of alkali in the tract, as shown by these surveys:

Quantity of Alkali in the First Four Feet of Soil in the Swan Tract.

Soil Sections	SEPTEMBER, 1902		MAY, 1903			OCTOBER, 1913		
	Alkali in 40a	Per cent of Total	Alkali in 40a	Per cent of Total	*Per cent Lost	Alkali in 40a	Per cent of Total	* Per cent Lost
1st Ft.	1363	20	499	14	63	101	8	92
2nd Ft.	1540	23	650	19	58	183	15	88
3rd Ft.	1766	27	1066	31	40	330	28	82
4th Ft.	1982	30	1265	36	36	607	49	69
Total	6651	.....	3480	.....	49	1221	.....	82

*Shows the proportion of the salts removed as compared with the salt originally present in the various depths.

The data given in the table shows that between September, 1902, and the following May, *3,171 tons* of salt had been removed from the soil to a depth of four feet, and that between September 1902 and the following October, *5,430 tons* had been removed, or *82 per cent* of the alkali originally in the first four feet of soil.

The tract was sown to fall rye during the fall of 1903 and this plowed under during the spring of 1904 in order to add humus to the soil. The land was then seeded to alfalfa with oats as a nurse crop. During 1904 a profitable crop of oats was secured and a uniform "stand" of alfalfa established. Since that time the alfalfa on this tract has run normal and healthy and the fact that the removal of alkali salts by drainage can be accomplished definitely proven.

Drainage of lands not only removes alkali but prevents water logging—promotes soil areation and is most desirable farm practice. It is to be hoped that the unsightly, forbidding, desolate stretch of waste alkali lands near Salt Lake City may be converted into beautiful fruitful fields of golden harvest, where now there is a dreary waste, through the process of drainage.

DRAINAGE A FACTOR IN THE FUTURE GROWTH OF SALT LAKE CITY

BY

R. A. Hart, Supervising Drainage Engineer U. S. Department of Agriculture.

It may sound antithetical to say that one of the most important factors of the future growth of Salt Lake City, the acknowledged capital of the arid west, is the drainage of agricultural lands, yet such a statement is capable of proof and it is the purpose of this article to impress upon the public generally the vital importance of this phase of reclamation work.

We must admit that agriculture is the fundamental basis of our existence and is the foundation of both manufacture and commerce. Utah is primarily an agricultural state and with all due respect to our mining and other allied industries, we are compelled to acknowledge agriculture as being the one stable producer of private necessities and public wealth.

Science is doing much to assist in the utilization of lands beyond the reach of irrigation water but "dry farming," as we choose to call it, must for the greater part be confined to the production of annual crops such as the grains, while hay, sugar beets, fruit, berries and garden truck must continue to be grown on irrigated lands. A wise Providence has made it possible to grow grain on the hilltops and the lands above the highest canals; reserving the bottom lands, where water may be more easily and cheaply applied, for hay, beets and vegetables, and the slopes for fruit and berries which require less water and better air and soil drainage.

The importance of artificial underdrainage may be realized when it is known that the amount of agricultural land in the state of Utah now unproductive or given over to wet pastures, for want of drainage, is equal to at least a fourth of the amount of land in the state actually being irrigated.

Much of this injured area has been productive and has been brought to its present condition through a too liberal use of irrigation water. A considerable area has always been in the condition in which we now see it. Much of the land in Utah that is in need of drainage does not present the appearance of a swamp to the eye. In truth much of it is dry on the surface and is covered with a deposit of powdered or crystallized salts, known popularly as "Alkali." These salts, however, indicate that for a part of each year at least the ground water reaches a dangerous proximity to the surface, such that through the action of capillary attraction and evaporation the salts are brought to and deposited upon the surface of the ground.

These salts are, of course, injurious to plant life as is indicated by the barren condition of the soil, or by the presence of certain alkaline resistent plants such as salt grass, greasewood, alkali heath, etc. It is

only necessary to provide ample underdrainage to a depth of six feet or more and then leach out the salts by a liberal application of irrigation water coupled to a vigorous cultivation of the soil. It is impossible to wash the salts from the surface by flushing. They must be dissolved and leached out into the underdrainage.

The presence of the salts on the surface indicates that the ground water is at such a height that plants would suffer even if there were no salts present so underdrainage serves a double purpose.

It behooves all citizens of this city and state to acquaint themselves with the needs and possibilities of drainage as a factor in agricultural development. The farmer must understand the situation, naturally, as he is directly in touch with it and there is no valley in the state in which the problem of water-logging has not been encountered and there are few individual farms that could not be improved by drainage. The banker should, by all means, understand the situation because lands injured by an excess of water or alkaline salts generally have a very low loan value when as a matter of fact most farms which are not paying taxes can be improved at a cost of from $15 to $25 an acre and be made to yield returns on a valuation of from $100 to $200 per acre. One of the greatest obstacles to drainage reclamation is the securing of sufficient funds to effect the reclamation. Business men, professional men, manufacturers, railroad heads and men in the building trades should understand the situtation because the future of their business in this section depends to a considerable extent upon this factor. This is true not only because of the present status but because the problem grows bigger as time goes on and each new irrigation development brings with it an increase in the acreage demanding reclamation by drainage. In fact all prudent irrigation companies make a comprehensive drainage system a vital part of their plans when they begin a new irrigation project and it is usually safe to avoid projects that advertise perfect natural drainage because this is only a relative term which applies before irrigation water is put upon the land, but cannot apply afterward. Even a high gravelly bench does not have perfect natural drainage as is witnessed by the fact that many such benches require drainage. Investors are becoming inbued with a new wisdom and their inquiry is not, "Is this soil well drained," but, "What provisions are making for artificial drainage" and "What are the possibilites of securng a satisfactory outlet for artificial drainage." There are few lands so badly alkaline in this state that they cannot be brought back to a high state of cultivation if proper methods are employed but it must be remembered that thorough underdrainage is the fundamental basis of all such reclamation work. A great deal of agitation is now going on throughout the state, looking toward such reclamation, and this will be followed by dishonest activities on the part of unscrupulous promoters to foist worthless lands upon the unsuspecting. It should be remembered that thorough underdrainage is a vital necessity in lands that are, have been or may become impregnated with alkaline salts.

It is not the intention of this article to attempt an enumeration of

all the sections of the state that may be benefited by drainage but in order to convince the skeptical of the seriousness and magnitude of the problem, attention will be called to sections more or less familiar to the general public.

If a trip to Ogden is made over the O. S. L. it will be observed that from Beck's Hot Springs to Kaysville there is a very little land in maximum producing condition west of the tracks and that in places the wet lands extend across the tracks and even beyond the Interurban line. This means that one of the richest valleys known is limited, to a width in places, of a fraction of a mile. Beyond Kaysville the Sand Ridge projects out into the valley and very little water-logged land is to be seen but much may be found in a short drive to the west. The seeped area is spreading and the farmers are very active along drainage lines in that section.

This injury will continue on up the slope and in case the Sand Ridge is irrigated much of the land below the O. S. L. tracks will require drainage.

West of Ogden is a great territory that should be thoroughly drained and continuing north of Ogden it will be observed that the productive area narrows down to a mere ribbon as far north as Brigham City. Beyond this point the Bear River Valley spreads out its great expanse. Thousands of acres of land in this valley have been reclaimed by drainage, by individuals and corporations, and much more remains to be done. Crossing over the divide we find a great tract of wet land in the very heart of Cache Valley.

Returning to Salt Lake City we are greeted by what has been aptly termed the "eye sore of Zion" that vast area of land lying to the west, unproductive and useless in its present state but inherently fertile and capable of producing rich returns if relieved of its excess water and properly cultivated and irrigated. Going south of Salt Lake, water-logged land may be found on both sides of the Jordan River while thousands of acres of land lie on three sides of Utah Lake, much which may be reclaimed by gravity canals and much by diking and pumping.

And so we might continue on down through central valleys of the state and then go either west or east to the various other valleys, old or new, but enough has been pointed out to set even the most skeptical to thinking and to open the writer to the charge of "knocking." It is not intended that the information herein given shall be detrimental to the interests of this city or state. The truth is good enough for Utah and investors are coming to appreciate the truth more than the lurid advertising which has been a curse to the west. All irrigated states are confronted with the problem of drainage, but Utah, the mother of Anglo-Saxon irrigation in the west also pioneered in the reclamation of over-irrigated lands by artificial underdrainage. The other states followed the lead and bid fair to outdo us in drainage activities. It behooves us, therfore, to bestir ourselves in an effort to regain our lost ground, prevent future injury, transform our "eye sores" into garden spots and fulfill our destiny of making the desert to blossom as the rose.

TILE DRAINAGE IN THE RECLAMATION OF WATER-LOGGED AND ALKALINE LANDS

BY

J. C. Wheelon, Chief Engineer, Utah-Idaho Sugar Co.

Though but little time has heretofore been given to lands which are not producing money crops, it appears that the cultivation of the waste places, and the reclamation of the vast tracts of land that are now idle and unproductive presents some valuable possibilities for the conservation and enhancement of the agricultural resources of the country. For, in agriculture even more than in other lines of science or business, it is necessary to plan constantly for future improvement and expansion.

While great efforts are being justly put forth to bring the new and as yet unclaimed desert under the life-giving influences of irrigation, a very large field of endeavor awaits those who will devote their attention to the reclamation of lands already under irrigation.

We may travel the length and breadth of the settled portion of Utah and we find on one side the bench lands which are thirsting for water, while on the other side we can see the lower lands giving up to the unequal contest against over-irrigation, and we find ourselves wondering which should have the first aid, the man dying of thirst or the one being drowned Personally, I am attracted to the drowning one as in no other way can we be so completely convinced that there is water to spare for all the needs of the thirsty one.

While we realize that we in Utah are still in the primer in the reclamation of water-logged and alkaline lands, yet the construction of seventy-five miles of farm drain tiling in Box Elder County on lands belonging to the Utah-Idaho Sugar Co., and others, has been both instructive and profitable.

We have learned that the salt grass and toole swales can be drained and made to yield the finest of wild hay, and the ground made dry and firm enough to admit teams and wagons; that water-logged and mineralized sage brush ground can be drained and made to produce oats and alfalfa and that old water-logged and non-productive farms can be drained and made to produce profitable crops. We finished the tile drainage of a field of sage brush in October (1912) and on August 20th, (1913) there was threshed from this field an average of 35 bushels of oats per acre and a fairly good stand of young alfalfa that was sown with the oats is now growing on the ground. This means that the ground was plowed, brushed, leveled, converted into a seed bed, harvested and threshed in less than ten months, four months of which was winter weather and unfit for working the land.

In August, 1910, the writer finished a tile drain system on sixty acres of water-logged and alkaline alfalfa land that had been cropped for several years before the water and mineral "took" it, the lands

were irrigated and twenty-two and a half acres of the most non-productive was measured and Fall plowed. The following Spring (1911) the plowed land was planted in oats and alfalfa and in the following August an average yield of fifty-one bushels of oats per acre was threshed from this twenty-two and a half acres of ground and a good stand of alfalfa was secured which is increasing in yield each year.

Mr. Mathew Baer, who is Superintendent of the Sommer's Ranches in Box Elder County and who has been draining lands for years both here and in the State of Illinois permits me to say for him that he feels safe in expecting enough increase in crop yield in the first following year to pay for the cost of tile drainage.

These results are due not alone to the mechanical improvement resulting from the placing of a drain system in the land, but rather to the competency of the system coupled with the most intelligent process of cultivation of the soil in order to renew its former consistency and bring about a proper granulation of the soil, flush from the surface the mineral concentrated there, thus reducing the quantity from a harmful to a helpful amount, and cause (also by irrigation) the redistribution of the helpful quantity down, and through the subsoil.

We have learned that a few essentials in the reclamation of this class of lands are of the utmost importance. The system must be a competent one. The placing of a line of drains through a field in a haphazard manner means but little toward a competent system. The lines should be laid at regular intervals of distances so that every foot of ground has nearly equal facility for relief. The lines should be about eighty to one hundred feet apart for each foot in depth, thus if the lines are laid four feet deep they should be from 350 to 425 feet apart, if they are eight or ten feet deep they can be 800 or 1000 feet apart according to the texture of the soils, the shallow lines for the more heavy clay, the deeper lines for the sandy and more porous soils. The outlet discharge should be in the open air and not submerged under the water of the stream or pond into which the soil waters may be emptied so that aeriation, which is so necessary to the invalided lands, can be effected by the air rushing into the tile over the flow line and thus reach the pores of the soil during the winter season when the surface is frost bound.

The land should be leveled and surfaced in such a manner that the first irrigation will cover every portion of the field so that the excess minerals will be dissolved and carried away in solution. The loss or retention of fertility in the soil during the period of their invalidity is a matter of much concern; it seems that where the "Black" alkali predominates the minerals, the humus contents of the soil are actually consumed, and while in all the alkalines there is at least a trace of "Black" alkali the soils and soil waters of Utah are so free from this destructive salt that we have seen vegetable and manure dressing remain intact during several years of soil inaction due to mineralization, when upon the reclamation of the lands the soil would respond to the influence of the fertilizer as readily as if the dressing had been recently applied.